RADIO ACCESS PACKET DATA BITRATE ESTIMATION FROM TERMINAL

TECHNICAL FIELD

The present invention relates to multi-radio access systems in general, specifically to a method and an arrangement for access selection in such systems.

BACKGROUND

At present, there is a wide variety of wireless and wire bound networks based on different radio access technologies (RAT) and standards. Each RAT has and will have its strengths and weaknesses with respect to capacity, cost, available data rates, and support for end user mobility. Consequently, no single RAT will be able to fully support all service and user requirements. Therefore, it is, and will be, necessary for users and their terminals to be able to utilize multiple accesses depending on the present requirements or requested service. Several multi-access scenarios will exist in the near future, for example comprising both Universal Mobile Telecommunications Systems (UMTS) and Wireless Local Area Networks (WLAN).

In prior art, it has been observed that the radio access is selected based on the radio quality, service type and load in [1]. Access point (cell) selection based on radio quality (handover) and load (load sharing) are established methods in cellular networks.

In the near future, several radio resource management (RRM) distribution scenarios will be possible [2], for example; "terminal controlled without network assistance". Probably also multi-operator subscription will become possible, at least for WLAN. Uncoordinated WLAN accesses already exist.

In all the above examples, a choice of radio access technology, radio network and/or access point has to be performed.

SUMMARY

A general object of the present invention is to enable an improved access selection mechanism in a multi-access system.

Another object is to enable a mechanism for access selection based on both radio quality and load or utilization for each access.

Yet another object is to provide a mechanism for access selection based on an estimated user perceived quality, estimated from load and radio quality.

Further objects of the present invention are

- to enable selecting an access giving the highest bitrate in a multi-access selection
- to enable selecting a network giving the highest bitrate, in a multi-operator selection
- to enable selecting an access point giving the highest bitrate, in an uncoordinated WLAN access point network
- to enable measuring data quality without accessing a network, in a measurement tool (TEMS),to enable improved handover.

These and other objects are achieved in accordance with the attached claims.

Basically, the radio access usage or load or utilization is measured by the terminal and used as a basis, typically in combination with other radio measurements, to estimate a user perceived quality measure such as the packet data bitrate of an access point or node.

Briefly, the present invention enables a user perceived data quality estimate prior to access, which takes load or utilization into account, enabling a terminal based best user quality access selection in a multi-access multi-operator environment

Advantages of the invention comprise:

- Enables estimation of data quality prior to access.
- Takes into account cell/AP load
- Enables best user quality multi-access selection without system coordination.
- Enables best user quality multi-operator selection without operator coordination
- Enables load sharing access selection based in terminal
- No impact on infrastructure
- Improved handover.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, together with further objects and advantages thereof, may best be understood by making reference to the following description taken together with the accompanying drawings, in which:

Fig. 1 illustrates a general multi-access system, in which the invention can be utilized,

Fig. 2 is a schematic flow diagram of an embodiment according to the invention,

Fig. 3 illustrates the effect of an embodiment according to the invention,

Fig. 4 illustrates the effect of another embodiment according to the invention,

Fig. 5 illustrates an embodiment according to the invention,

Fig. 6 illustrates an example according to an embodiment of the invention,

Fig.7 illustrates another example according to an embodiment of the invention,

Fig. 8 illustrates an embodiment of an arrangement according to the invention.

DETAILED DESCRIPTION

In Figure 1, a schematic illustration of a multi-radio access scenario is shown. Accordingly, the scenario comprises a mobile communication terminal that is able to communicate with at least one of a plurality of accesses or access networks. At some point in time, the terminal needs to be able to select at least one of the plurality of accesses.

The load or utilization of an access network has a large impact on the packet data rate [3]. The existing load sharing mechanisms, both cell selection and radio access selection [1], are network based. In a less coordinated scenario, such solutions are not possible or at least very complicated. Also, it is of little interest from the operator to support load information to the terminal or user.

The user is also more interested in quality i.e. user perceived quality Q_u, than overall capacity of the network or system, while the operator in some cases can have contradictory interests.

Throughout the description, the term load is interchangeable with the term utilization or utilization factor, which represents the utilization of at least one access point/base station in an access network. It does not represent a total load in a whole access network.

According to a general embodiment, the present invention basically comprises estimating user perceived data quality Q_u prior to access, which takes load or utilization into account, thereby enabling a terminal based best user quality access selection in a multi-access multi-operator environment.

According to another general embodiment, the invention comprises determining the radio quality for a plurality of available accesses, determining a load or utilization factor for each of the accesses, estimating a user perceived quality based on the

determined quality and load, and finally selecting at least one access which gives the best user perceived quality, thereby providing an improved access selection.

One embodiment of a method, according to the invention, will be described with reference to Fig. 2, which illustrates a schematic flow diagram of an embodiment of a method for improved access selection.

Initially, in step S1, the radio quality q for one or more available accesses is determined. These accesses can comprise access points or base stations or the like within a common network such as WLAN, or different access networks utilizing the same or different RAT, or different access networks belonging to one or different operators, or any combination thereof.

According to a specific embodiment, the determining step S1 comprises the further intermediate step of estimating a radio link bitrate μ for each access, based on the determined radio quality q, according to:

$$\mu=g(q) \qquad \text{Eq.1}$$

where μ is the radio link bitrate, and g is an access specific function. Accordingly, μ can be determined as a function of any one of pilot signal strength, beacon signal strength, C/I, or Eb/N0, or other quality parameter such as bit/block/packet-error rate.

The terminal can estimate μ prior an access as the expected coding and modulation rate. The value of μ can be specific for each terminal, or optionally constant or the same for each terminal and depend on the signal strength from the various accesses.

In the subsequent step S2, the utilization factor ρ or load for at least one node in at least one available access network is determined. The node can comprise any one of an access point, or base station, or the like.

For For Time Division Multiple Access (TDMA) systems e.g. GSM/GPRS/EDGE, the load or utilization factor ρ for an access point/base station or access network can be measured as the fraction of activation, according to [5].

Also, according to the invention, the server utilization factor ρ or load can be measured by the terminal as the fraction of activation on the carrier frequency (mainly for WLAN, but also for downlink Wideband Code Division Multiple Access (WCDMA) and CDMA2000). The utilization factor can also be explicitly signaled from the access point.

For WCDMA and CDMA2000 it can be measured as the load factor, see [4], according to:

$$\hat{\rho} = 1 - \frac{P_{CCH}}{P_{tot}} \qquad \text{Eq.2}$$

The common power P_{CCH} can be estimated out from the received pilot power and the total power P_{tot} out from the received wideband signal strength:

$$\hat{\rho} = 1 - \frac{F_{cch} \cdot SS_{pilot}}{SS_{tot}} \qquad \text{Eq.3}$$

where F_{CCH} is a factor that compensates for the other common channels such as the broadcast channel. This can result in an overestimation of the load for the multiple cell case, since SS_{tot} will include signals transmitted from several cells in the area. This error will be significant only in handover (HO) areas, and will have impact on the quality of user perceived data quality determination, but it can still be used for access selection.

Further, in step S3, the user perceived data quality Q_u for each access or access network is determined, based on the radio quality as represented by μ, and the

utilization factor ρ or load for at least one node in at least one available access network.

According to one embodiment, the user perceived data quality Q_u can be represented by an estimation of the Circuit Switched Equivalent bitrate (CSE-bitrate). CSE is defined as "the number of information bits delivered divided by the time when there were bits to deliver".

According to another embodiment, the user perceived data quality Q_u can be represented by an active session throughput, as defined in UMTS30.03 [6].

There is a clear correlation between the user perceived data quality and carrier frequency load. According to an embodiment of the present invention, the user perceived data quality Q_u can be estimated according to:

$$Q_u = \mu \cdot (1 - \rho) \qquad \text{Eq.4}$$

where μ is the radio link bitrate [kbps], ρ is the utilization factor ($0 < \rho < 1$). In Fig. 3, where the user perceived data quality is represented by the CSE-bitrate; the absolute utilization or ρ*system capacity* is the x-axis, *E[CSE]* is the y-axis and μ is the intersection of the y-axis of the indicated dashed line.

It is also possible to use the same expression/expressions to estimate a data throughput, not as accurately as for CSE but enough to give a rough estimate of the parameter.

According to a more generalized embodiment, the user perceived data quality Q_u can be determined according to:

$$Q_u = \mu \cdot f(\rho) \qquad \text{Eq.5}$$

where μ is the radio link bitrate and f is a known access specific function. One example of an access which could be estimated by such an expression is shown in Fig.4, where the user perceived data quality Q_u is represented by the Circuit Switched Equivalent bitrate (CSE).

Optionally, the CSE-bitrate can be determined based on a comparison of a maximum bearer rate and one of the above expressions, whereby the best estimate is the lower of the two values.

Finally, in step S4, the access with the best user perceived data quality Q_u is selected by the terminal. The selection enables any one of the following:

- best user quality multi-access selection without system coordination.
- best user quality multi-operator selection without operator coordination
- load sharing access selection based in terminal,
- improved handover

In addition to the above described relations, the coverage could also be taken into account. With knowledge of the power limits for the radio links and path loss to the server the maximum bit rate can be calculated, e.g. in WCDMA if there is coverage for a 384 kbps bearer.

It is also possible to use some other parameter to represent the user perceived quality of an access, such a parameter is the active session throughput. This can be estimated in the same manner as above, but with a somewhat lower accuracy. It is however possible to use as a rough estimate, which at least improves the chance for the terminal to receive a better quality.

An example of an embodiment of the present invention will be described below, with reference to Fig. 5.

Consider a terminal 10 according to the invention, such as a mobile unit, that encounter the situation where it has to select one of a WLAN-network 20 and a WCDMA HS-network 20. Initially, the terminal 10 measures the radio signal strength or radio signal quality for WLAN and WCDMA, respectively. Consequently, it is possible to estimate μ for the two systems 20.

According to the example, the radio signal quality measurement results in q_1=1dB for WLAN and q_2=3dB for WCDMA. Using the g-functions provided in Fig. 6 and Fig. 7, these in turn lead to μ_1=5Mbps for WLAN and μ_2=3Mbps for WCDMA.

It is understood that Fig. 6 and Fig. 7 only serve as examples and are not to be viewed as the only manner in which to determine μ.

Secondly, the terminal 10 measures the utilization factors ρ_1 and ρ_2 representing the usage for the WLAN-network 20, and the usage according to Equation 2 for the WCDMA HS-network 20. Suppose that ρ_1=0.7 and that ρ_2=0.3.

In a subsequent step, the terminal estimates CSE for the two systems 20 according to Equation 4 (or Equation 5), e.g. $E[CSE]=\mu(1-\rho)$. Accordingly, $E[CSE]_{WLAN}=5*(1-0.7)=1.5$ Mbps and $E[CSE]_{WCDMAHS}=3*(1-0.3)=2.1$ Mbps.

Based on the estimated CSE for the two systems 20, the terminal 10 selects to connect to or utilize access WCDMA HS.

Figure 8 shows an embodiment of a mobile communication terminal 10 according to the invention. The terminal 10 comprises an input/output unit 11, a unit 12 for determining the radio quality for a plurality of accesses, a unit 13 for determining the load or utilization factor of at least one access point for each of the plurality of accesses, a unit 14 for determining a user perceived data quality based on the determined radio quality and utilization, and selecting unit 15 for selecting at least one access based on the determined user perceived data quality..

The radio quality determination unit 12 can be further configured to estimate the radio link bitrate as a function of the radio quality. Thereby, the user perceived data quality is determined based on the radio link bitrate and the utilization.

Optionally, the load or utilization determining unit 13 can be adapted to receive a signaled load from an access point or other component of the multi-access system, or the load unit 13 can be adapted to perform measurements and determine load on its own.

The estimated CSE-bitrate can ultimately be used for a number of purposes, not only access selection, including some non-multi-access related:

- In a multi-access selection, to select the access giving highest bitrate.
- In a multi-operator selection, to select the network giving highest bitrate.
- In an uncoordinated WLAN AP network, to select the AP giving highest bitrate.
- In a measurement tool (TEMS), to estimate data quality without accessing the network.
- In a handover selection situation.

It is understood that the invention is equally applicable to access selection for cases where the accesses i) belong to the same operator or different operators, ii) belong to the same or different radio access technologies, and iii) belong to the same or different access networks.

It will be understood by those skilled in the art that various modifications and changes may be made to the present invention without departure from the scope thereof, which is defined by the appended claims.

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